Jun 29th, 10:20 AM - 10:40 AM

Session A7- Rapid assessment of road-stream crossings for aquatic organism passage

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The Nature Conservancy
Protecting nature. Preserving life.™

UMassAmherst Outreach UMass Extension

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Rapid Assessment of Road-Stream Crossings for Aquatic Organism Passage

River and Stream Continuity Partnership

- University of Massachusetts Amherst
- The Nature Conservancy
- MA Riverways Program
- American Rivers

River & Stream Continuity Project


Micrographia


Alan Richmond


Micrographia


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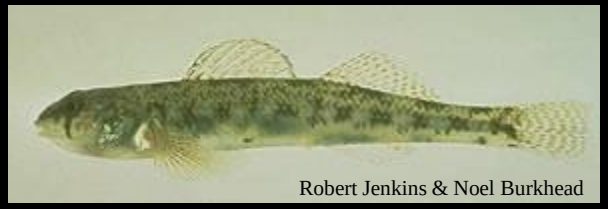
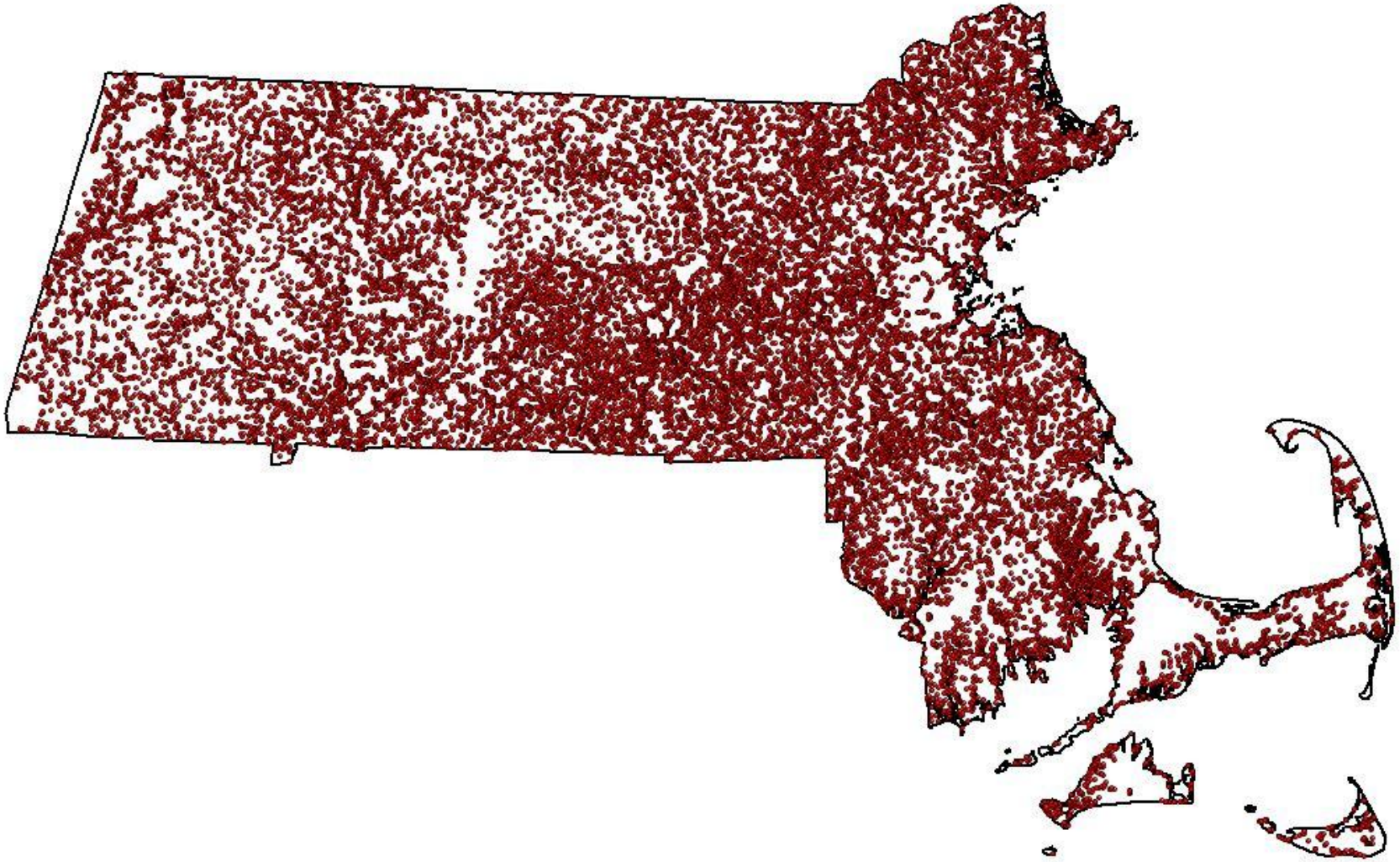
Barry Wicklow


Robert Jenkins & Noel Burkhead

Ecosystem Restoration Via Crossing Upgrades

- Systematic evaluation of river and stream crossings
- Evaluation of habitat quality and landscape considerations
- Establish priorities for upgrades
- Careful design and construction
- Permitting



Assessment Field Forms

5/27/2010

Data entry by _____ Date _____
Reviewed by _____ Date _____

Field Data Form: Road-Stream Crossing Inventory

Coordinator _____ **Crossing ID#** _____
Stream/River: _____ **Road:** _____ **Town:** _____
Flow condition: ☐ Unusually low ☐ Typical low-flow ☐ Average flow ☐ Higher than average

GPS Coordinates (lat/long):
☐ Decimal degrees N___ ___ . ___ ___ ___ ___ ___ W___ ___ . ___ ___ ___ ___ ___
OR ☐ Degrees, minutes, seconds North: D _____ M _____ S _____
West: D _____ M _____ S _____

Date:_____ **Location:** _____ **Observer:** _____
Photo IDs: _____

Road/Railway Characteristics

1. **Road surface:** ☐ Paved ☐ Unpaved
2. **Road type:** ☐ 1-Lane road ☐ 2-Lane road ☐ Multilane road (>2 lanes) ☐ Divided highway ☐ Railroad

Crossing/Stream Characteristics (during generally low-flow conditions)

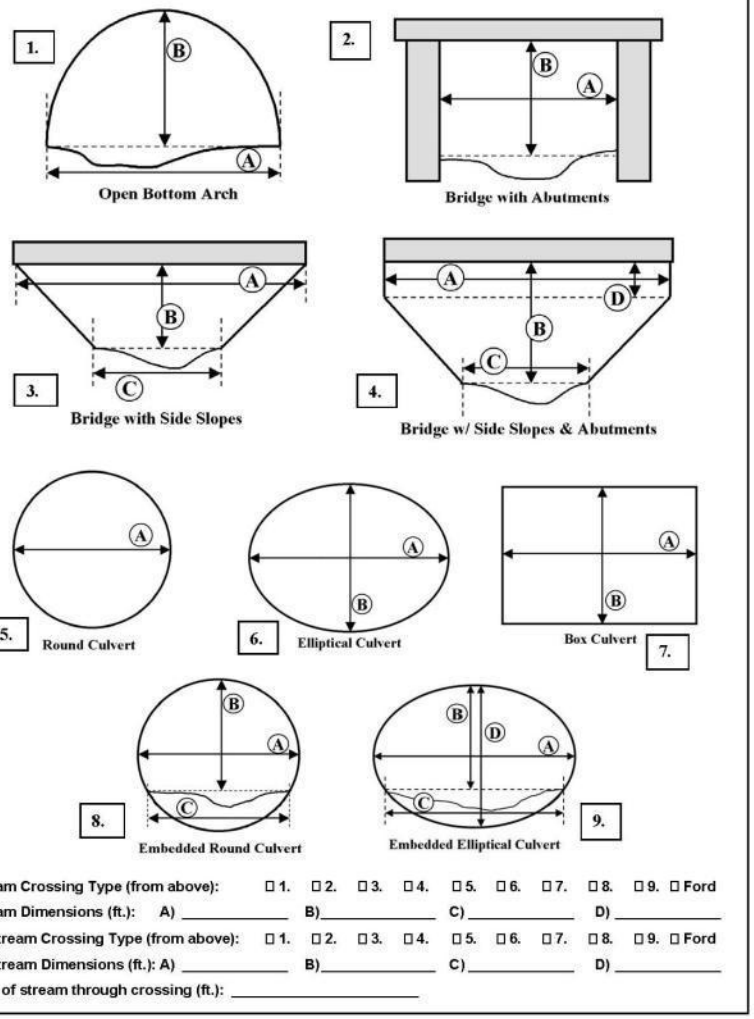
3. **Crossing type:** ☐ Ford ☐ Bridge ☐ Open bottom arch ☐ Single culvert ☐ Multiple culverts (# of culverts)_____
4. **Condition of crossing:** ☐ Excellent ☐ Fair ☐ Poor
5. **Does the stream at the crossing support fish?** ☐ Yes ☐ Not likely ☐ Don't know
6. **Is the stream flowing?** ☐ Yes ☐ No
7. **Structure height at low water** _____ Feet ☐ Measured ☐ Estimated
   (from water level to the roof inside the structure)
8. **Inlet Drop** _____ Inches ☐ Measured ☐ Estimated
9. **Outlet Drop**
   a. **Culvert bottom to water surface**_____ Inches ☐ Measured ☐ Estimated
   b. **Culvert bottom to stream bed**_____ Inches ☐ Measured ☐ Estimated
   c. **With an outlet drop, check one**: ☐ Cascade ☐ Freefall ☐ Freefall onto cascade
10. **Armored streambed at outlet:** ☐ Extensive ☐ Not extensive ☐ None
11. **Crossing embedded?** ☐ Not embedded ☐ Partially embedded ☐ Fully embedded ☐ No Bottom
12. **Crossing substrate:** ☐ None (smooth) ☐ None (rough/corrugated) ☐ Inappropriate ☐ Contrasting ☐ Comparable
13. **Physical Barriers to fish and wildlife passage:** ☐ Severe ☐ Moderate ☐ Minor ☐ None
    Describe any barriers: _____

For the following questions use as a reference a portion of the natural stream channel that is outside the influence of the crossing structure and not otherwise altered.

14. **Crossing span:** ☐ Severe constriction ☐ Mild constriction ☐ Spans bank to bank ☐ Spans channel & banks
15. **Scour pool:** ☐ None ☐ Small (wider or deeper than natural stream) ☐ Large (width or depth 2X natural stream)
16. **Water depth matches stream?** ☐ Yes (comparable) ☐ No (deeper) ☐ No (shallower) ☐ Dry
17. **Water velocity matches stream?** ☐ Yes (comparable) ☐ No (slower) ☐ No (faster) ☐ Dry
18. **Crossing Slope matches stream?** ☐ Yes (comparable) ☐ No (flatter) ☐ No (steeper)
19. **Comments** _____

5/27/2010

CROSSING DIMENSIONS



Upstream Crossing Type (from above): ☐ 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐ 8. ☐ 9. ☐ Ford
Upstream Dimensions (ft.): A) _____ B) _____ C) _____ D) _____
Downstream Crossing Type (from above): ☐ 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐ 8. ☐ 9. ☐ Ford
Downstream Dimensions (ft.): A) _____ **B)** _____ **C)** _____ **D)** _____
Length of stream through crossing (ft.): _____

River & Stream Continuity Online Crossings Database

Reports | Edit Coordinators | Add Coordinator | Edit Observers | Add Observer | Add New Crossing | LogOff

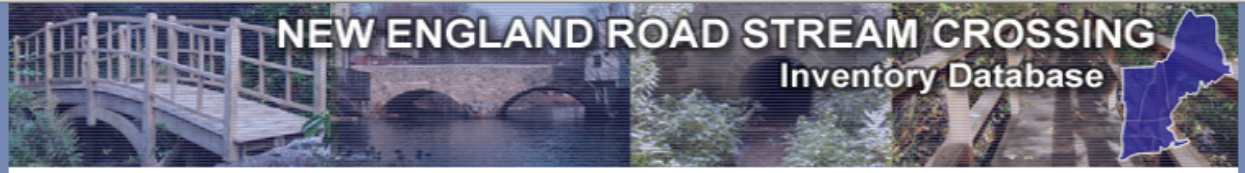
Please click on the map or on the link below to select your state:

Massachusetts | Vermont | New Hampshire | Connecticut | Rhode Island | Maine

Massachusetts Road Stream Crossing Inventory 2009

You are: sjackson [L3]

Data Input Screen



Reports | Edit Coordinators | Add Coordinator | Edit Observers | Add Observer | Add New Crossing | LogOff

Field Data Form: Road-Stream Crossing Inventory for "MA"

Coordinator: Scott Jackson [0] **Crossing ID:**

Flow condition: ○ Unusually low ○ Typical low-flow ○ Average flow ○ Higher than average

Date (m/d/yyyy): 07 / 21 / 2010 **Stream:** **Road:** **Town:** --

Location: **GPS Coord:** *in 00.0000 format(?)* Lat: . Long: -.

Observer: --

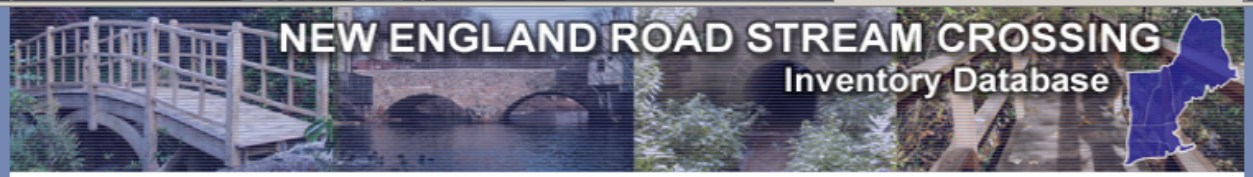
Road/Railway Characteristics:

1. **Road Surface:** ○ Paved ○ Unpaved ○ Railroad
2. **Road Type:** ○ 1-Lane Road ○ 2-Lane Road ○ Multilane road (>2 lanes) ○ Divided Highway ○ Railroad ○ Buried stream segment

Crossing/Stream Characteristics (during generally low-flow conditions)

3. **Crossing Type:** (*Additional culverts can be described on the next page*) ○ Ford ○ Bridge ○ Open Bottom Arch ○ Single Culvert ○ Multiple Culverts ○ Removed Structure
4. **Condition of crossing:** ○ Excellent ○ Fair ○ Poor
5. **Does the stream at the crossing contain fish?** ○ Yes ○ Not Likely ○ Don't know
6. **Is the stream flowing (in the natural channel)?** ○ Yes ○ No
7. **Minimum structure height at low water?** (from water level to the roof inside the structure) ○ < 4 ft. ○ 4-6 ft. ○ > 6 ft.
8. **Inlet drop** ○ None ○ 1-6" ○ 6-12" ○ 12-24" ○ >24"
9. **Outlet Drop**
   - a. **Culvert bottom to water surface:** ○ None ○ 1-6" ○ 6-12" ○ 12-24" ○ >24"
   - b. **Culvert bottom to stream bed:** ○ None ○ 1-6" ○ 6-12" ○ 12-24" ○ >24"

Data Reports



Reports | Edit Coordinators | Add Coordinator | Edit Observers | Add Observer | Add New Crossing | LogOff

Road Stream Crossings:

Location:
Rhode Island [560]
All RI Towns/cities
All RI Streams
ID:

Personnel:
Any Observer
Any Coordinator
25 per page
Search

Criteria:
All Standards
From ... 8/5/2002
To... 7/21/2010
Only Active

SB - Severe Barriers, **MDB** - Moderate Barriers, **MIB** - Minor Barriers, **MGS** - Meets General Standards, **MOS** - Meets Optimum Standards

Export: Simple, Meaningful, Comprehensive Results to Excel

Showing 560 Records, 25 per page.

Next [535]

Date	ID	Town	Stream	Road	St'd	Culv.	Open
2006/02/18	010900050102-C-0155	Hopkinton RI	No Name	Canonchet Rd	MDB	1	0.054
2008/09/11	010900050205-PM-045	Hopkinton RI	No Name	Woodville Rd.	MIB	2	0.050
2008/09/18	010900050205-PM-044	Hopkinton RI	Tomaquag Brook	Nooseneck Hill Rd.	MDB	1	0.083
2008/09/18	010900050205-PM-043	Hopkinton RI	No Name	Nooseneck Hill Rd.	MIB	1	0.048
2008/09/18	010900050205-PM-040	Hopkinton RI	Tomaquag Brook	Woodville Rd.	MIB	1	0.085
2008/10/09	010900050205-PM-039	Hopkinton RI	No Name	Nooseneck Hil Rd.	MIB	1	0.044
2008/09/11	010900050205-PM-036	Hopkinton RI	No Name	Woodville Rd.	MDB	2	0.098
2008/08/23	010900050205-PM-035	Richmond RI	Meadow Brook	Pine Hill Rd.	MDB	1	0.620
2008/11/02	010900050205-PM-034	Richmond RI	Meadow Brook	Meadow Brook Trail	MDB	1	0.048
2008/11/02	010900050205-PM-033	Richmond RI	Meadow Brook	Meadow Brook Trail	MIB	1	0.262
2008/08/28	010900050205-PM-030	Richmond RI	White Brook	Mill St.	MIB	1	0.060
2008/08/23	010900050205-PM-028	Richmond RI	No Name	Unnamed-24	MIB	1	0.037

View Specific Records

General Information for Road-Stream Crossing ID: **820010151-C-20**

820010151-C-20-20100603-I.jpg

820010151-C-20-20100603-O.jpg

Coordinator: Sue Flint Crossing ID: 820010151-C-20

Flow condition: Unusually low

Date: 06-03-2010 Stream: unnamed StreamID: 820010151-C- Road: Commonwealth Avenue Town: Concord, MA

Location: Old Pail Factory Bridge GPS: Lat: 42.4586 Long: 71.3919

Observer: John Phone: 978-371-0871 Email: cyber2jlc@comcast.net

Photo IDs:

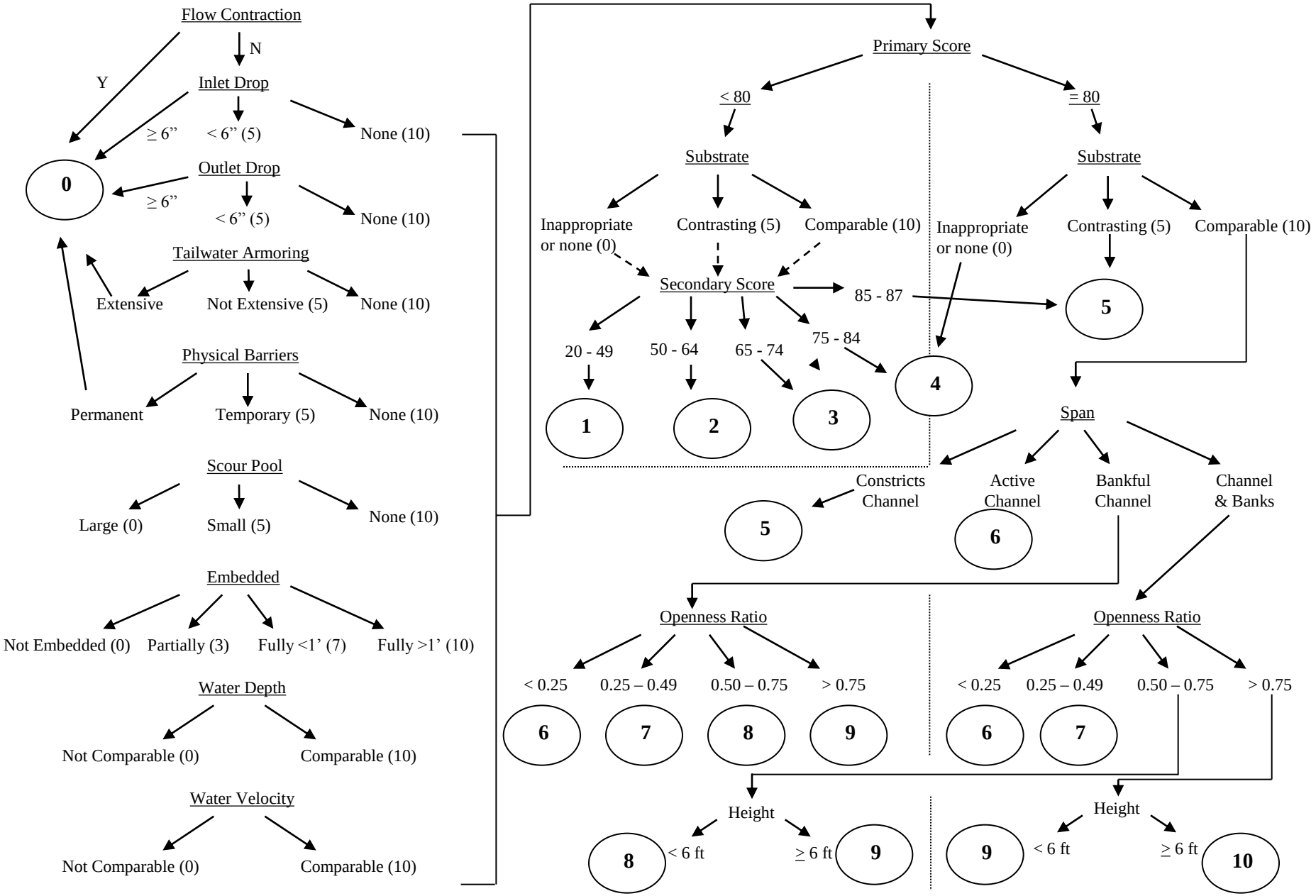
Road/Railway Characteristics:

1.	Road Surface:	Paved
2.	Road Type:	

Crossing/Stream Characteristics *(during generally low-flow conditions)*

3.	Crossing type:	Open Bottom Arch
4.	Condition of crossing:	Fair
5.	Does the stream at the crossing contain fish?	Yes
6.	Is the stream flowing (in the natural channel)?	Yes
7.	Minimum structure height at low water:	> 6 ft.
8.	Inlet drop:	No
9.	Outlet Drop:	
	a. Culvert bottom to water surface:	No
	b. Culvert bottom to stream bed:	
	c. With an outlet drop, check one:	
10.	Armored streambed at outlet?	None
11.	Crossing Embedded?	No Bottom
12.	Crossing substrate?	Comparable

MA Crossing Structures Scoring System



Testing the Protocol
Objectives

- Assess the accuracy of crossing surveys
- Assess the repeatability (precision) of surveys
  - conducted by different observers
  - conducted at different times of year (different flows)
- Evaluate the database scoring algorithm

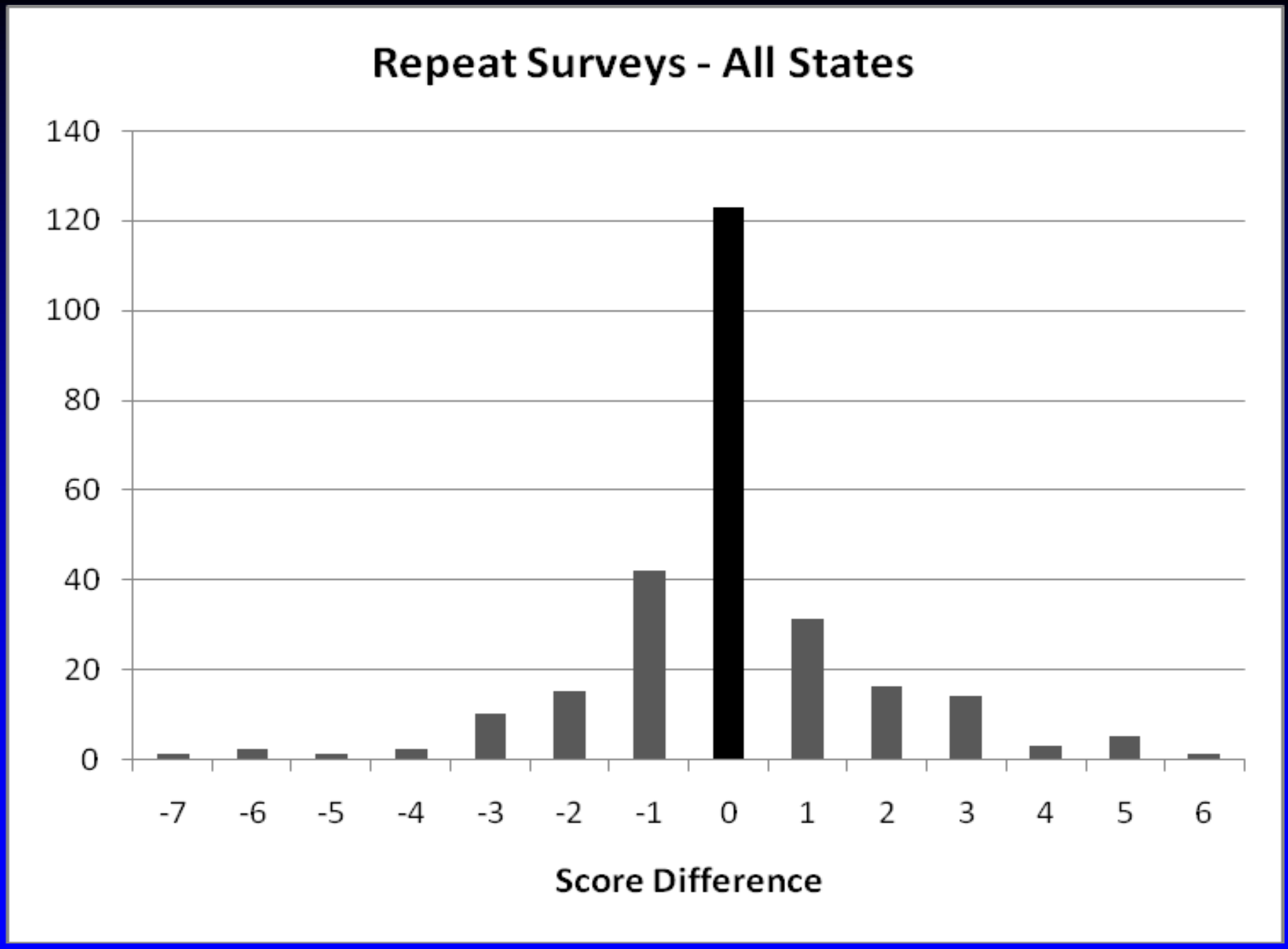
Methods

- Resurveyed 317 crossings in CT, MA, NH & VT
  - Previous survey vs. resurvey
  - Different flows vs. Similar flows
  - Technician surveys at different flows
- 116 Sites evaluated with other fish passage assessment methods
  - Continuity Crossings Database
  - FishXing
  - Coffman Coarse Screens
  - CA Salmonid Coarse Screen

Results

For 51 of the 317 sites (16.1%) it was likely that the surveys were not conducted on the same crossings

	Percent of Differences All States	Percent of Differences CT	Percent of Differences MA	Percent of Differences NH	Percent of Differences VT
High traffic volume	3.8	4.1	3.8	7.7	0.0
Road surface	4.1	0.0	3.8	7.7	5.0
Jersey barriers	4.1	16.3	1.9	1.9	0.0
Crossing type	6.4	14.3	8.6	1.9	0.0
Shoulder	10.2	10.2	9.5	9.6	11.7
Fencing	14.3	14.3	18.1	5.8	15.0
Inlet drop	14.7	2.0	18.1	13.5	20.0
Structure height	15.8	8.2	22.9	19.2	6.7
Travel lanes	16.2	4.1	7.6	36.5	23.3
Outlet drop	19.2	6.1	21.9	26.9	18.3
Crossing embedment	24.1	38.8	18.1	36.5	11.7
Tailwater armoring	24.4	18.4	31.4	23.1	18.3
Water velocity	28.9	32.7	21.9	34.6	33.3
Scour pool	31.2	32.7	25.7	32.7	38.3
Water depth	31.2	30.6	27.6	42.3	28.3
Physical barriers	32.0	22.4	34.3	25.0	41.7
Crossing substrate	33.1	36.7	22.9	73.1	13.3
Steep embankments	39.5	32.7	61.0	46.2	1.7
Flow contraction	43.2	46.9	34.3	46.2	53.3
Retaining walls	45.9	30.6	68.6	61.5	5.0
Crossing span	47.4	36.7	55.2	48.1	41.7
Crossing Score	53.8	67.3	52.4	53.8	45.0
Crossing condition	56.0	55.1	43.8	100.0	40.0
Flow conditions	60.2	36.7	63.8	59.6	73.3
Points	77.1	81.6	74.3	84.6	71.7

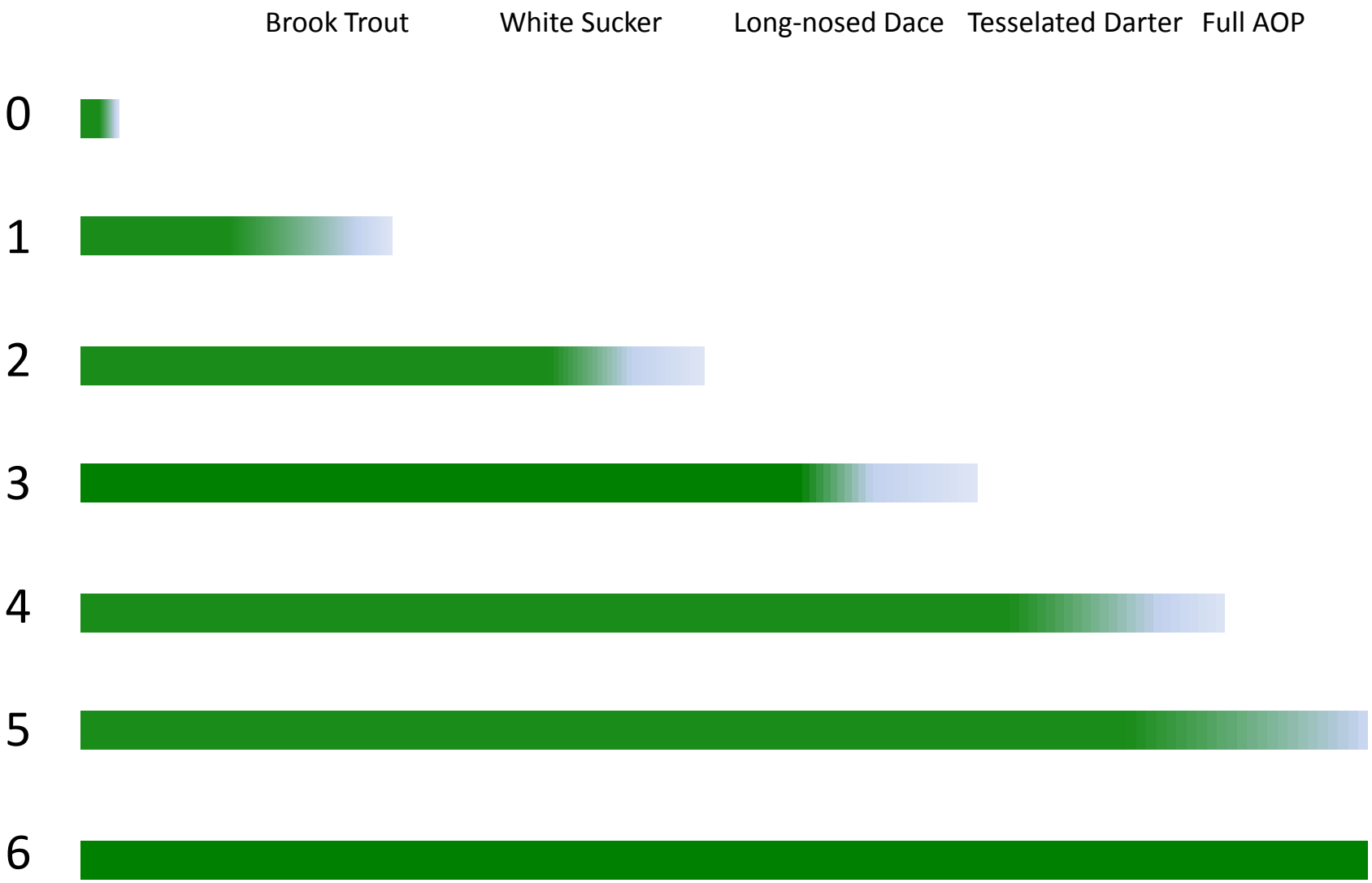

Repeat Surveys - All States
140
120
100
80
60
40
20
0
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Score Difference

Affect of Flow Conditions

	Mean Percent Differences		Mean Change in Points		Mean Change in Score	
	Similar Flow	Different Flow	Similar Flow	Different Flow	Similar Flow	Different Flow
CT	22.0	23.2	-5.23	-11.28	0.00	-0.78
MA	25.2	27.9	-3.11	0.43	-0.84	-0.18
NH	35.3	29.5	11.43	8.29	1.05	1.00
VT	19.3	19.4	-0.12	-2.11	0.62	0.18
All States	24.7	24.8	-0.73	0.18	-0.02	0.10

*Previous survey minus resurvey scores

Continuity Project Scoring Algorithm: Aquatic Passage



AOP
Aquatic Organism Passage

FishXing

Software and Learning Systems for Fish Passage through Culverts

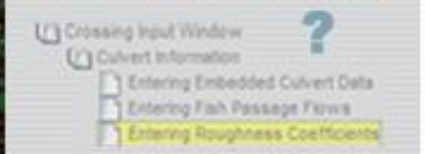
Home . Software . Multimedia . Resources . User Manual

Pronounced "Fish Crossing",

This software is intended to assist engineers, hydrologists, and fish biologists in the evaluation and design of culverts for fish passage. It is free and available for download. Version 3 of FishXing is in its final beta form.

New Additions

Have you seen the
FishXing Help Manual



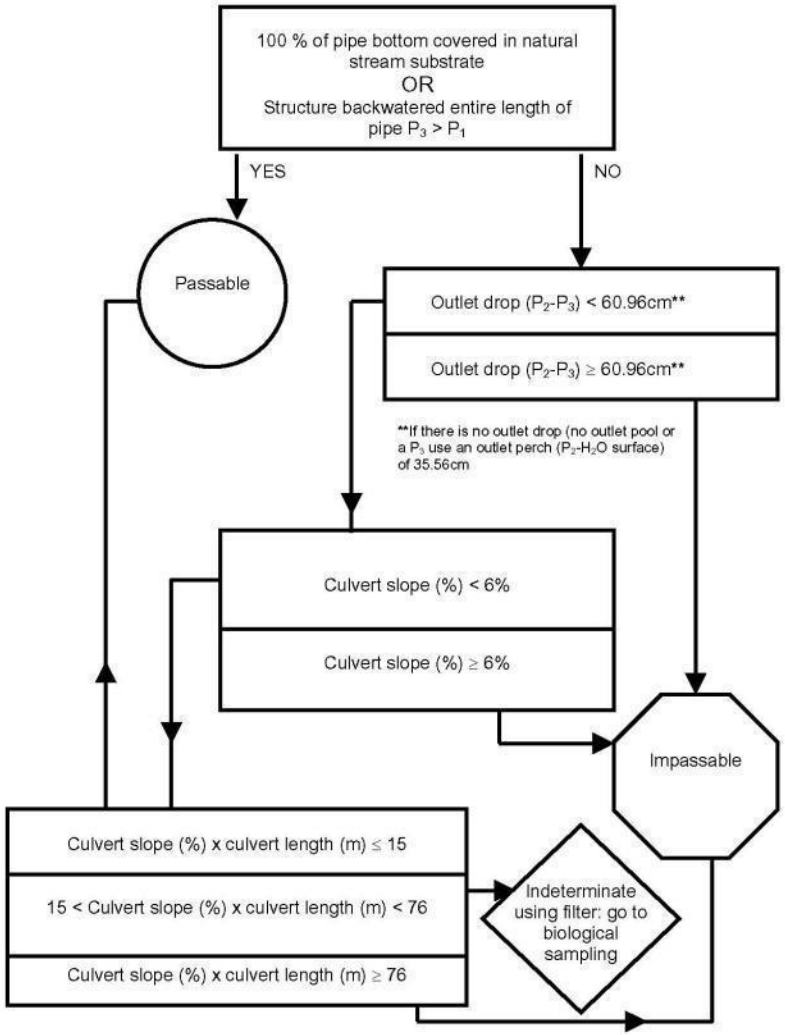


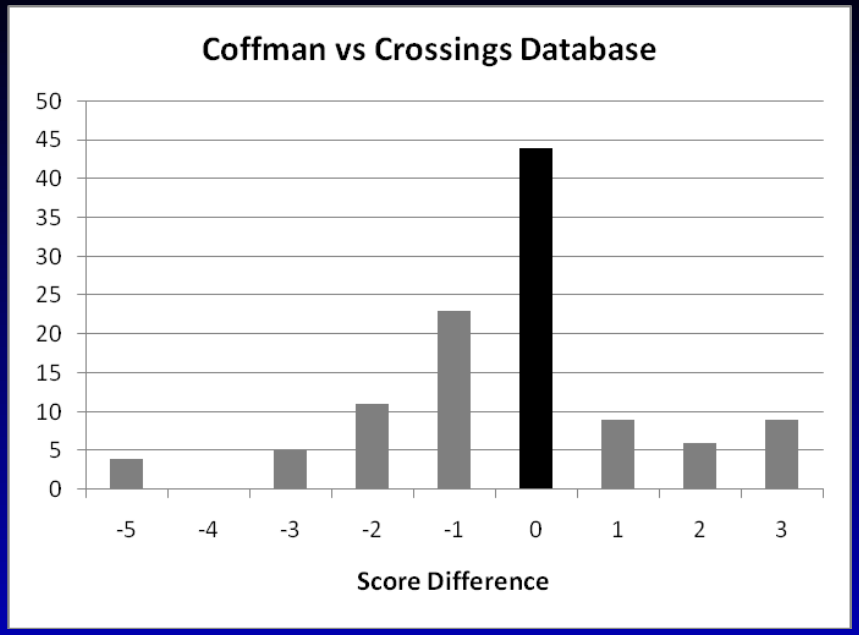
Figure 1.2. Upstream fish passage predictive model A for Salmonidae. See Figure 1.1 for profile of survey points used in fish passage predictive model. P_n = elevation measurements.

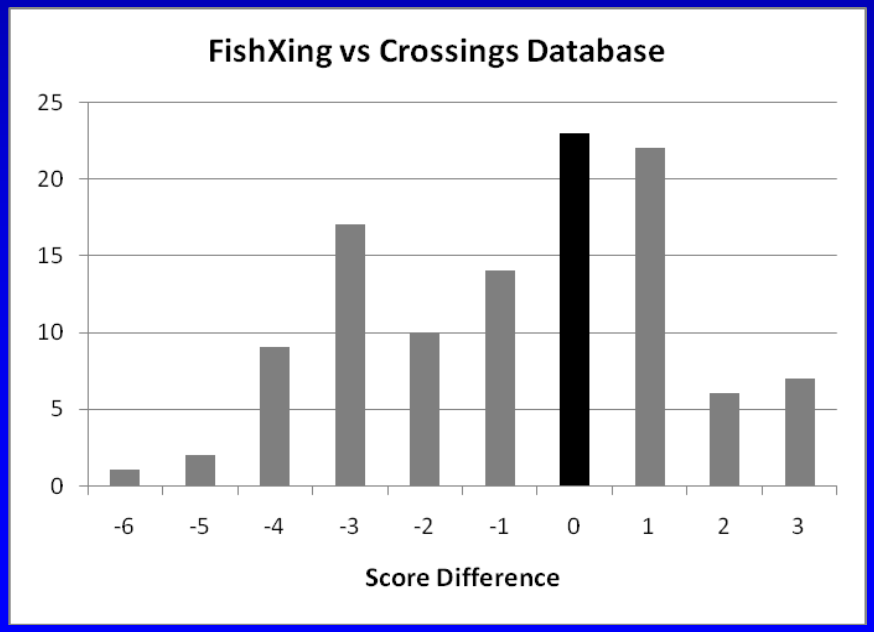
Course Screens

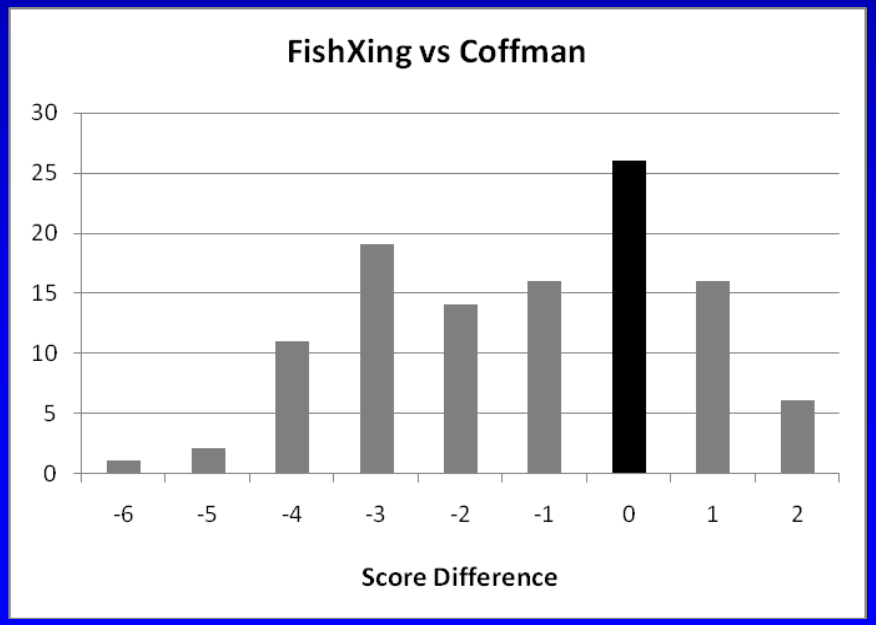
- California Salmonid
- Coffman MS Thesis

Scoring

Score	Passability
0	Impassable or largely impassable for all species
1	Passable for adult brook trout for part of the year
2	Full passage for brook trout
3	Full passage for white sucker; partial passage for long-nosed dace
4	Full passage for long-nosed dace; partial passage for tessellated darter
5	Full passage for all species
6	Full fish passage plus structural elements present


Coffman vs Crossings Database
50
45
40
35
30
25
20
15
10
5
0
-5
-4
-3
-2
-1
0
1
2
3
Score Difference


FishXing vs Crossings Database
25
20
15
10
5
0
-6
-5
-4
-3
-2
-1
0
1
2
3
Score Difference


FishXing vs Coffman
30
25
20
15
10
5
0
-6
-5
-4
-3
-2
-1
0
1
2
Score Difference

General Standards

- Open bottom spans are strongly preferred
- If a culvert, then it should be embedded
- Spans streambed and banks (at least 1.2 x bankfull)
- Natural substrate
- Water depths and velocities comparable to those found in the natural channel at a variety of flows
- Openness> 0.82 feet (0.25 meters)
- Banks should be present on each side of the stream matching the horizontal profile of the existing stream and banks

Selecting Variables for Inclusion

Rapid assessment approach constrains options

- Must be relatively easy to evaluate in the field in a single visit
- Observable with only limited access to the site
- For use by volunteers or field technicians
- No surveyed elevation data

Crossing Span

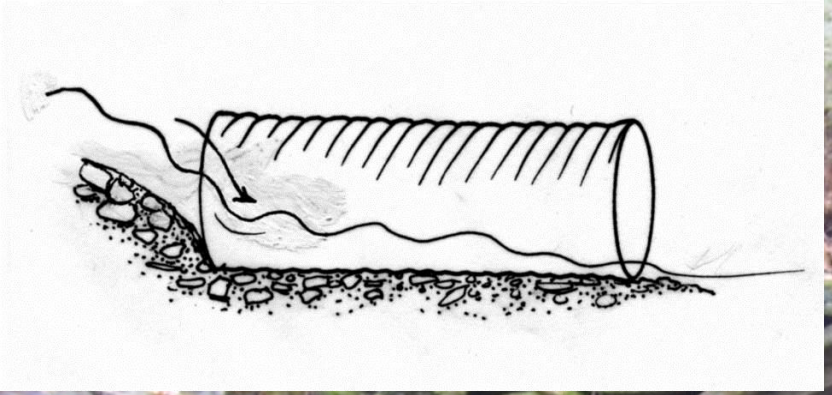
Severe Constriction: Crossing is half as wide, or narrower than the bankfull width of the natural stream.

Mild Constriction: Crossing is narrower than bankfull width in the natural channel upstream and downstream of the crossing, but not enough to qualify as a severe constriction.

Crossing Span

Spans Bank to Bank: Crossing spans the bankfull width of the channel, but does not include the banks of the stream.

Spans Channel and Banks: Crossing structure spans bankfull width and one or more of the banks with sufficient headroom to allow dry passage for some wildlife.



Inlet Drop

- ☐ Measured
- ☐ Estimated

Outlet Drop Measurements

- Culvert Bottom to Water Surface
- Culvert Bottom to Stream Bed

☐ Measured
☐ Estimated

Physical Barriers

Culvert Inlet

Physical Barriers

- Severe
- Moderate
- Minor
- None

Beaver fencing

Crossing Embedded?

Embedment

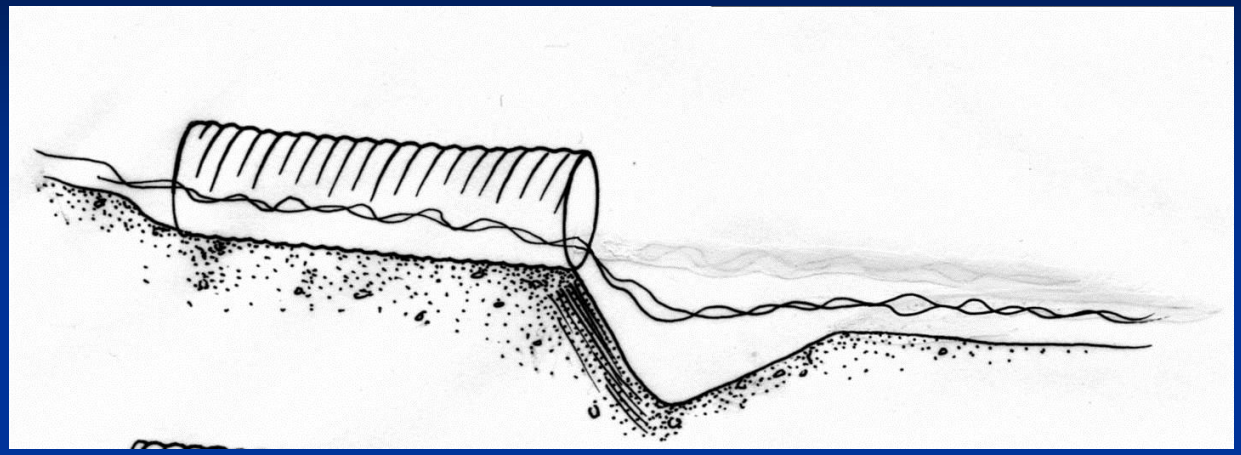
- Not embedded
- Partially embedded
- Fully embedded
- No bottom

Crossing Substrate

Substrate

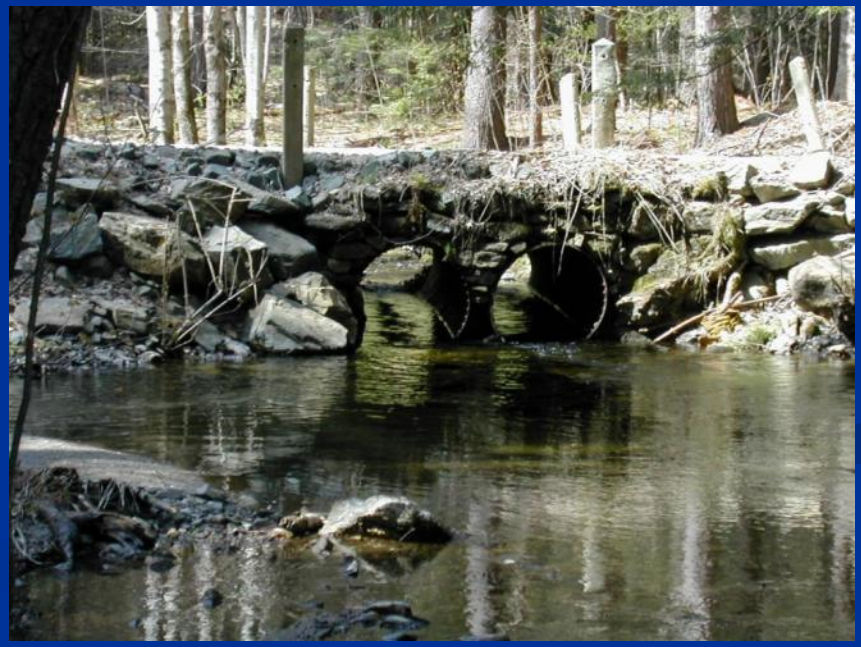
- None (smooth)
- None (roughened/corrugated)
- Inappropriate
- Contrasting
- Comparable

Scour Pool?

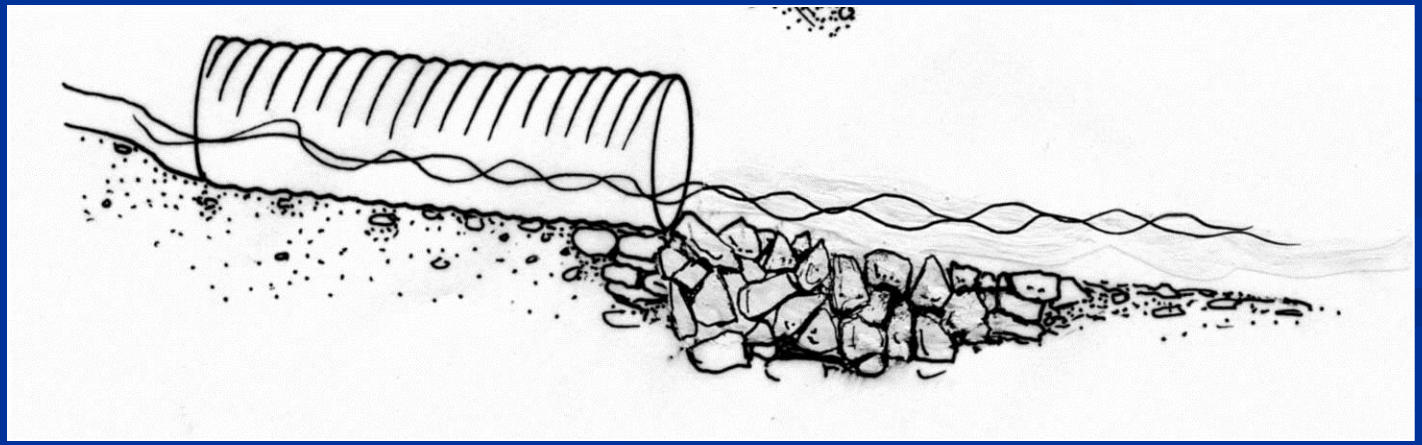


Scour Pool

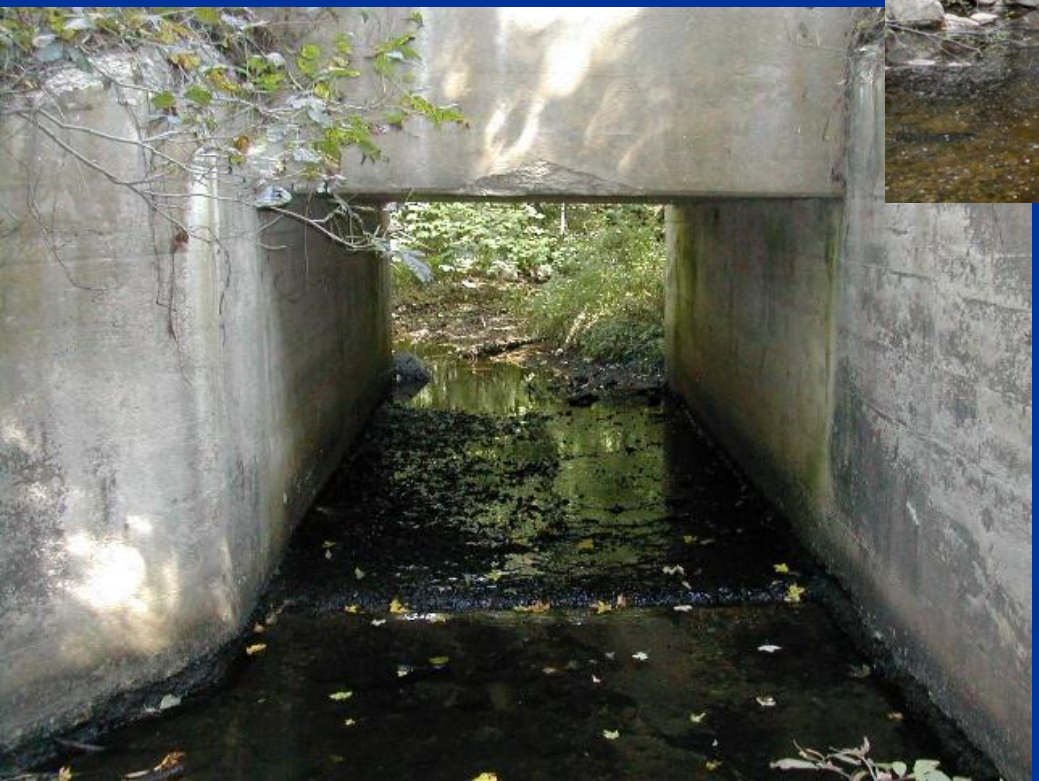
- None
- Small
- Large



Tailwater Armoring

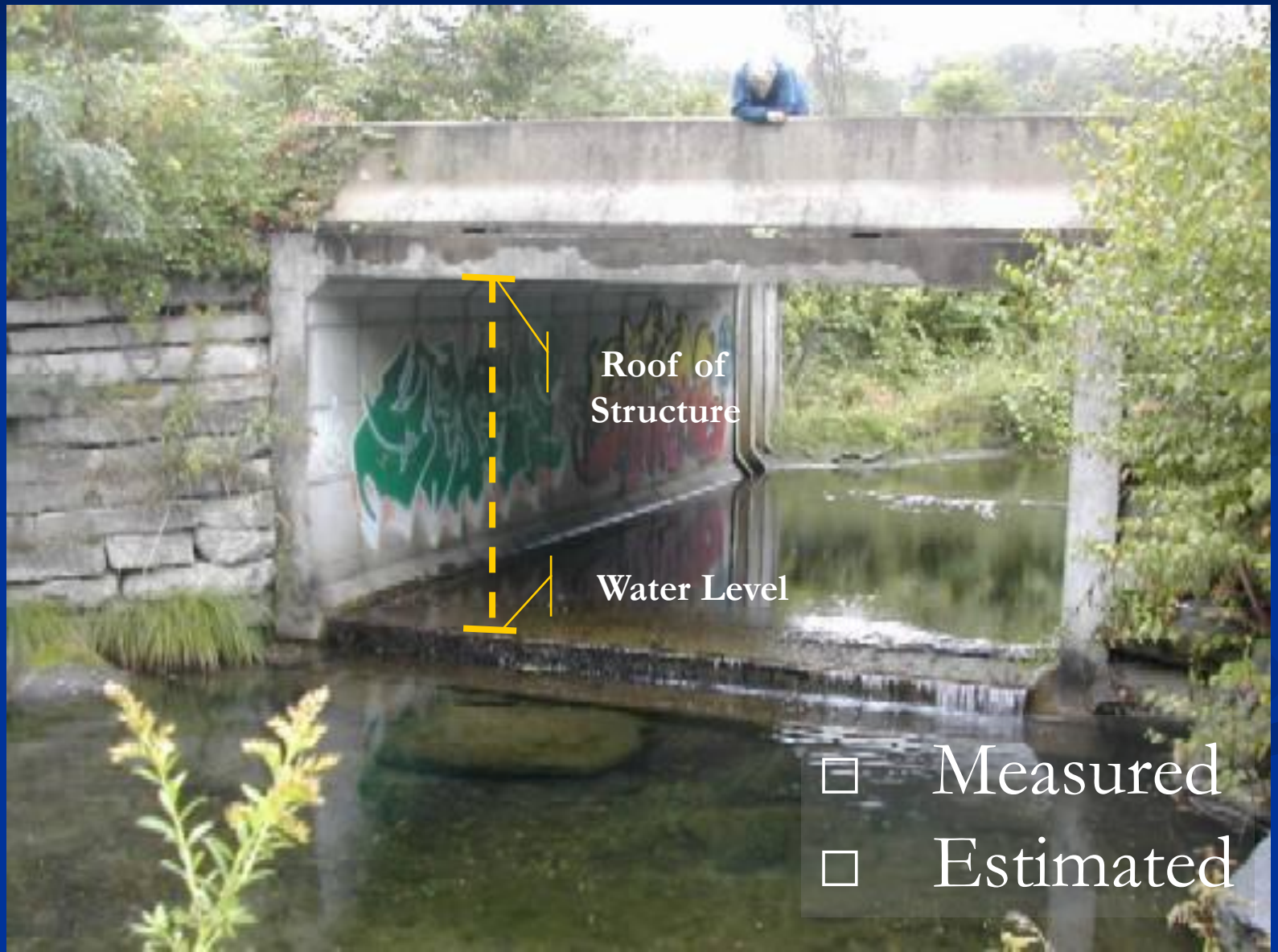


Water Depths, Velocities, Slopes



- Comparable
- Contrasting
  - Deeper/shallower
  - Slower/faster
  - Flatter/steeper
- Dry

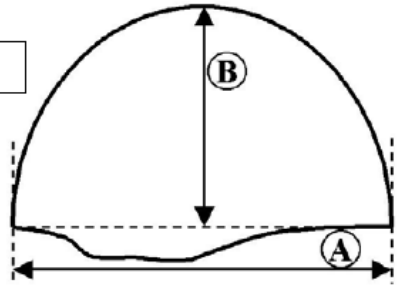
Structure Height at Low Water?



CROSSING DIMENSIONS

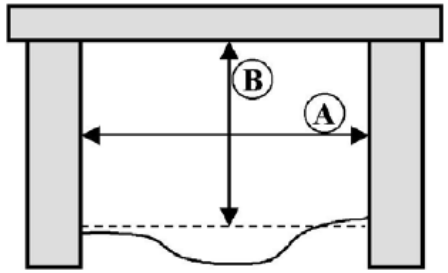
Crossing Dimensions

1.

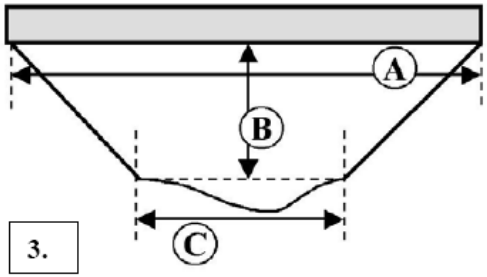


Open Bottom Arch

2.

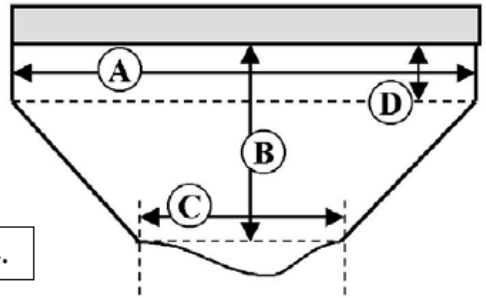


Bridge with Abutments



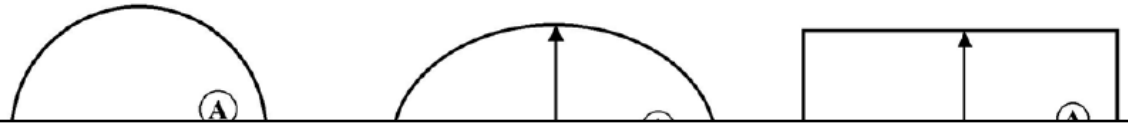
3.

Bridge with Side Slopes



4.

Bridge w/ Side Slopes & Abutments



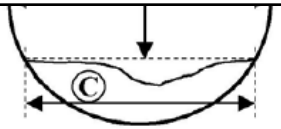
Upstream Crossing Type (from above): ☐ 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐ 8. ☐ 9. ☐ Ford

Upstream Dimensions (ft.): A) _____ B) _____ C) _____ D) _____

Downstream Crossing Type (from above): ☐ 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐ 7. ☐ 8. ☐ 9. ☐ Ford

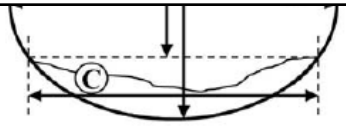
Downstream Dimensions (ft.): A) _____ B) _____ C) _____ D) _____

Length of stream through crossing (ft.): _____



8.

Embedded Round Culvert



9.

Embedded Elliptical Culvert

Scoring Algorithm

parameter	weight
outlet.drop	0.149
physical.barriers	0.107
water.velocity	0.104
water.depth	0.098
inlet.drop	0.093
crossing.span	0.089
crossing.substrate	0.084
crossing.embedment	0.083
openness	0.061
scour.pool	0.058
tailwater.armoring	0.041
height	0.033

Scores range from 0-1

Conclusions

- Repeat surveys of crossing structures indicate relatively high rates of discrepancies for particular data fields but small overall effects on crossing scores
- It is important to collect sufficient data to accurately document crossing locations
- Flow conditions may not be a critical factor in timing field surveys
- FishXing is difficult to implement unless detailed hydrological data are available for target sites

Conclusions

- It is difficult to implement FishXing or develop crossing assessment models without significantly more research on swimming and leaping ability of New England fish and data from field studies on passability of culverts for a broad range of species
- In the absence of empirical data, expert opinion models such as the Continuity Scoring Algorithm may be a reasonable approach for assessing the barrier effects of road-stream crossings

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